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II. "On the Production of the so-called 'Acute Cestode Tuberculosis' by the administration of the Proglottides of *Tænia mediocanellata*." By JAMES BEART SIMONDS, Esq., Professor of Cattle-Pathology in the Royal Veterinary College, and T. SPENCER COBBOLD, M.D., F.R.S., F.L.S. Received April 13, 1865.

Neither of us having exhausted certain funds placed at our disposal for scientific purposes (in the one case by the Royal Agricultural Society through the Governors of the Royal Veterinary College, and in the other by the British Association for the Advancement of Science), we have united the resources which severally remained to us, and have instituted a series of experiments in helminthology. These experiments, we are happy to state, have proved, for the most part, eminently successful; moreover, several of them not having been previously performed in this country, we have ventured to think that at least the firstfruits of our combined research in this particular relation might not unfitly be submitted to the notice of the Royal Society.

The subject selected for the experiment which we now proceed to relate, was a fine healthy female calf about a month old, living at the time on the milk of its dam. As we were unable to obtain possession of the dam, another cow was procured as a foster-mother, and the calf was placed with her in order that it might receive a proper supply of milk in the natural way. This plan was preferred to that of obtaining a weaned calf, as being better calculated to preserve the health and strength of the young animal. In the course of a few days the two animals became perfectly accustomed to each other, the calf taking nourishment as often as was requisite.

On the 21st of December, 1864, we administered to the calf eighty mature proglottides of the *Tænia mediocanellata*, mingled with a little warm milk in the form of a draught. The potion was taken readily, and the worm-joints probably entered the stomach in a perfect and unbroken condition. No alteration was made in the subsequent management of the animals, but a careful daily watch was kept upon the calf.

For some time no indications were perceived of disturbed health; but on the 6th of January, 1865 (the sixteenth day after the experiment), a careful observation showed that the animal, although lively (and taking its milk and likewise some hay with undiminished appetite), was nevertheless suffering from some persistent cause of irritation. It would often be nibbling at its legs and other parts of its body, and trying with its mouth and tongue to get at places which were beyond its ordinary reach. It would also frequently rub itself against the manger and sides of the loose box in which it was confined. Desisting from this, it would arch its spine and stretch out its hind limbs in an altogether unusual manner. It would also strain itself repeatedly, at such times voiding either urine or fæces, or occasionally both in small quantity. There was, however, no expression of suffer-

ing in the countenance, no disturbance of the breathing or of the circulation, no injection of the visible mucous membranes, no alteration of the temperature of the body, no "staring" of the coat, nor rigors; in short, no indication of anything seriously wrong. These symptoms continued throughout the next day with little variation; on the third day they had nearly passed away, and by the fourth had entirely disappeared.

On the 25th of January, 1865, just five weeks after the first worm-feeding, two hundred more of the mature proglottides of *Tænia medio-canellata* were administered; but one hundred of these worm-segments had been previously immersed in a weak alcoholic solution, strong enough, it was feared, to destroy the vitality of their contained eggs. The other hundred proglottides were in beautiful condition, and for the most part appeared to be thoroughly mature. Again the calf took the feeding readily, and little or no force had to be employed in holding it during the administration. However, directly on being loosed, it was observed to show some symptoms of distress in the breathing, accompanied with trembling. The feeding took place at 3 P.M., and, as the night promised to be cold, it was placed with the cow in a closed and warm stable. On the following morning it was noticed that the tremors had somewhat abated, but the animal was evidently dispirited, and would every now and then grind its teeth as if in pain. Its appetite was much diminished. By the next day, however, all these diseased symptoms passed away, and the animal recovered its ordinary healthy aspect.

On the 1st of February, the seventh day succeeding the second worm-feeding, there was a decided return of the nervous irritability; but in a day or two these symptoms again declined. Nevertheless the animal was not quite right; the coat began to lose its natural and glossy appearance, and there was an evident loss of flesh.

Feb. 8th.—A marked change for the worse has taken place. The animal is dull and dispirited; refuses all food excepting milk, and of this takes but little; it arches the back frequently, and stretches the limbs in a peculiar manner; the breathing and the pulse have increased, and at intervals slight tremors are observable, more particularly of the muscles of the neck and shoulders.

Feb. 9th.—All the unhealthy symptoms are more marked. The pulse numbers 120, and the breathing 35 in the minute. The tremors are more continuous, and the condition of the animal is fast declining.

Feb. 10th.—Still worse. The calf is so ill that we fear a fatal result. It takes little or no notice of the cow, and cannot be induced to suck. The eyes have a peculiar staring expression.

Feb. 11th.—The severity of the symptoms has somewhat abated this morning. The animal is rather more lively, and will now and then take a little milk. The breathing and pulse, however, remain rapid. The tremors, though still frequent, have diminished in intensity. Towards the after part of the day the improvement became more marked; therefore,

instead of destroying the animal (as we had purposed in the event of its becoming much worse), we resolved to satisfy ourselves, by other means, as to whether the above symptoms were really due to parasite-invasion. Accordingly a small portion of the right sterno-maxillaris muscle was removed by operation, and this fragment of the flesh, although weighing only 22 grains, revealed the presence of three imperfectly developed cysticercus-vesicles. Each was about the size of a pin's head, but they displayed no trace of calcareous corpuscles, or of cephalic formation in their interior. On the assumption (afterwards, however, found to be erroneous) that all the muscles of the body might be similarly affected, and to the same extent, it was at the time calculated that the animal "entertained" some 30,000 of these artificially introduced "guests."

Feb. 12th.—A further improvement has taken place, but the animal is still dispirited, the pulse and breathing continuing abnormally rapid. The eyes are less staring.

Feb. 13th.—Improvement continues; breathing less rapid; the tremors have disappeared.

Feb. 15th.—Pulse diminishing; breathing nearly normal; appetite good.

Feb. 22nd.—Convalescence perfectly re-established.

Throughout the remainder of the month of February, and during the whole of March, the calf continued to maintain complete vigour, and, indeed, gained flesh so rapidly that at the beginning of April it might readily have been sold to a farmer, to a butcher, or to a cattle-dealer, as a thoroughly sound and thriving young beast. The time having, however, arrived for determining the result of the experiment, the calf was slaughtered on the 3rd of April, by division of the right carotid artery. The operation was performed by Mr. Pritchard, who also during the subsequent *post-mortem* examination rendered us essential service. As before, so after its death, all present remarked the particularly healthy aspect of the animal, there being no external indications by which the most practised professional eye could have discovered the existence of internal disease. But for our previous trial we should ourselves have been doubtful of finding any entozoa within the flesh.

Immediately after the first incision along the median line of the thorax, a solitary cysticercus came into view; many others successively displaying themselves as the integument was being raised and dissected from off the left side of the carcass. No person in this country having hitherto witnessed such a demonstration as now followed, we may perhaps be permitted to express the feeling of astonishment which all shared on thus beholding hundreds of larval cestode parasites in the flesh of an animal not usually considered capable of harbouring "measles" after the fashion of swine.

Examined individually, the larvæ were enclosed in oval sacs, whose transparency permitted us to see, at or near the centre of each vesicle, internally, a minute white spot representing the so-called receptaculum capitæ.

On subsequent rupture of the cyst, a microscopic examination of the contained larva revealed the ordinary characters of the *Cysticercus* which produces the *Tenia mediocanellata*.

Speaking generally, it may be said that the connective tissue and cellular aponeuroses were very feebly invaded; but in certain situations, such as those occupied by the linea semicircularis and fascia lumbaris, several vesicles were closely associated; moreover, as regards the muscles themselves, extensive parasitic invasion was prevalent only in the more superficial layers. It was likewise noticed, as obtains in the parallel case of *Trichina*, that the larvæ were disposed in the longitudinal direction of the muscular fibres, being at the same time more numerous grouped towards the points of osseous insertion or of aponeurotic attachment. Not a few large vesicles had inflamed and suppurated, the cysts being occupied internally by a thick green-coloured deposit.

Referring to the left side only, we noted that all the breast-muscles (pectoralis major, p. transversus, and p. anticus) were much infested, but scarcely so fully as the more superficial panniculus carnosus. In the latissimus dorsi and trapezius the cysts were very numerous, rather less so in the combined levator humeri and sterno-occipitalis, somewhat fewer in the rhomboideus brevis and rhomboideus longus, and exceedingly scanty in the superior part of the scalenus, the remainder of this last-named muscle being entirely free. The lateralis sterni contained none; neither were any observed in the abdominal region of the serratus magnus, but several vesicles were lodged in the superficial cervical portion of this muscle. Not a few existed in the upper part of the complexus major and in the complexus minor, some also occurring in the longissimus dorsi; yet none were observed in the spinalis dorsi, in the superficialis costalis, or in the diaphragm.

Turning towards the neck-region, we found them abundant in the sterno-maxillaris, considerably less so in the splenius, only one in the hyoideus, several in the sterno-hyo-thyroideus, but none in the longus colli. All the other deep-seated muscles of this region, including the obliquus capitis superior and inferior, as well as the rectus capitis posticus major and minor, appeared free from any trace of the vesicles. On the other hand, all the superficial muscles of the face, such as the retractor anguli oris, orbicularis oris, and levator palpebrarum, gave abundant evidence of their presence, the vesicles being particularly numerous at the outer part of the masseter externus. In like manner their presence was only less strongly indicated in the muscles of the eyeball, such as the obliquus inferior, adductor and retractor oculi, also in the depressor oculi, one "measle" being placed between the tendon of this last-named muscle and the sclerotic coat. The ball of the eye itself contained no vesicles. A few were remarked in the substance of the genio-hyoideus and other muscles supplying the tongue; but the lingual organ properly so called appeared to be entirely free.

As regards the anterior extremity, we found the *Cysticerci* very numerous in the *teres externus* and *abductor humeralis*, being scarcely less abundant in the *spinatus anticus* and *posticus*. They were likewise prevalent in the front part of the *triceps extensor brachii*, but altogether wanting behind and in the deeper portions of this muscle. A very few were remarked in the *flexor brachii*, whilst the *subscapularis*, *teres internus*, and *coraco-humeralis* failed to reveal any. They were very abundant in the *flexor metacarpi externus*, less so in the *flexor metacarpi medius*, and comparatively scanty in the *flexor metacarpi internus*. The lower part of the combined *flexor perforatus* and *perforans* showed a few, several being likewise present in the *accessorius ulnaris*. They were rather more abundant in the *extensor metacarpi magnus*, also in the *extensor et adductor digitorum*, likewise in the *extensor digiti externus*, and scarcely less so in the *extensor metacarpi obliquus*; yet none could be discovered either in the *anconeus* or in the *humeralis externus*.

Over the haunch, and throughout the surface-flesh of the left hinder limb, the *Cysticerci* were particularly abundant, being numerous in the *gluteus maximus*, in the *tensor vaginæ femoris*, and most especially in the large *triceps abductor femoris*. They were little less abundant in the *vastus externus*, and in those limited portions of the *gastrocnemius externus* and *internus* which come near the surface. A few vesicles were observed at the subcutaneous posterior section of the *ischio-tibialis*, also in the outer part of the *biceps rotator tibialis* and *rectus femoris*; yet none were noticed either in the *gluteus internus* and *gracilis*, or in the *vastus internus* and *sartorius*. In the *flexor metatarsi* and *extensor pedis* they were rather numerous, but, at the same time, comparatively scarce in the *peroneus* and *flexor pedis perforans*. Lastly, none were detected in either the *psoas magnus* or *psoas parvus*.

With the exception of the heart, none of the viscera showed *Cysticerci*, the lungs, liver, kidneys, spleen, and thymus gland being absolutely free; neither were any discovered in the brain. In short, it may be stated that the internal organs of the body generally were perfectly healthy; and even as regards the heart itself, the rather numerous vesicles found there displayed only a very incomplete development. At first they looked as if they might belong to a separate swarm-brood; but a careful microscopic examination disproved this notion, and at the same time revealed some curious facts. In the heart none of the vesicles had attained one-third of the size of those prevalent in the muscles, yet their age was doubtless the same; for although none of those examined displayed a well-formed head with the characteristic and normal number of suckers, yet one vesicle was found to possess three suckers, another having two suckers, and a third only a single sucker. Most of the vesicles were entirely suckerless, whilst those which had them showed other indications of abnormality. The suckers themselves were not perfectly formed, in most cases, and there were commencing signs of calcareous degeneration. In some instances, the entire contents of the vesicles

appeared to have been absorbed, leaving only faint white spots to indicate the situations where the cysts once were. Such, at least, is our interpretation of the phenomena observed; and, in this relation, we have only further to remark that the heart-cysts were not merely found at the surface of the organ, but were dispersed throughout its substance, one or two of the better-formed vesicles being lodged within the septum ventriculorum.

On the present occasion we do not propose to offer any lengthened comment on the results of this experiment, but rather to let the facts speak for themselves; nevertheless, to impart an aspect of completeness to our paper, we will offer one or two concluding remarks.

So far as we are aware, only three experiments of this kind have been previously performed on the calf—namely, two by Leuckart, and one by Mosler. In two of these instances the experimental animal perished, whilst in the other case, as in our own, the creature barely escaped with its life. To our animal we administered a larger number of proglottides than had been given even in Mosler's case; but, probably in consequence of the embryonic immaturity of the contents of many of the eggs, we did not get that fatal result which otherwise would inevitably have followed from a larger migration of the cestode-progeny. We believe that by far the greater proportion of the "measles" resulted from the second worm-feeding, in which case they would have come from the hundred proglottides not subjected to the action of alcohol. Although the characters presented by the earlier-developed morbid symptoms, as well as the time of their accession, induce us to attribute the diseased phenomena to the larvæ set free by the first "feeding," yet it is clear, from the feebleness of the symptoms manifested, that only a very inconsiderable number of embryos can have entered on their wanderings. In the second "feeding," however, the case is very different; for here all the circumstances connected with the subsequent and marked disturbance of the animal's health point unequivocally to the development of that peculiar form of parasite-disease which Leuckart has designated as the "acute cestode tuberculosis."

From the number of young vesicles present in the minute portion of muscle removed by operation from the living animal, we had (in the pages of the 'Lancet') publicly announced our belief that we might ultimately find 30,000 Cysticerci developed in this calf; but as the larvæ were subsequently found to be almost entirely confined to the superficial muscular layers, it turned out that our calculation was considerably beyond the mark. Nevertheless from *post-mortem* data we estimate that there were between seven and eight thousand "measles" present, and one of us counted 130 vesicles at the surface of a single muscle.

Lastly, it only remains for us to express our thanks to those gentlemen who supplied us with the necessary experimental material, namely, to Dr. Greenhow for the first tapeworm employed, and to Dr. Anderson and Mr. Brookhouse (Nottingham) for the second and third tapeworms, which were given together at the second administration. Dr. Greenhow's specimen

had the head perfect, both his and Dr. Anderson's examples being quite fresh. Mr. Brookhouse informed us that his specimen had been placed in "very weak spirit"; but it is clear that the worm had been injuriously affected thereby, and the ova had lost their vitality.

III. "On the Rate of Passage of Crystalloids into and out of the Vascular and Non-Vascular Textures of the Body." By HENRY BENCE JONES, A.M., M.D., F.R.S. Received April 26, 1865.

(Abstract.)

The paper is divided into five sections—

- 1st. On the method of analysis, and its delicacy.
- 2nd. Experiments on animals to which salts of lithium were given, upon the rate of their passage into the textures.
- 3rd. On the rate of the passage of lithium-salts out of the textures.
- 4th. Experiments on healthy persons, and on cases of cataract.
- 5th. On the presence of lithium in solid and liquid food.

1. Three methods of analysis were followed, according as much or little lithium was present: first, simply touching the substance with a red-hot platinum-wire; secondly, extracting the substance with water; thirdly, incinerating the substance and treating it with sulphuric acid, and exhausting with absolute alcohol.  $\frac{1}{12,000,000}$  of a grain of chloride of lithium in distilled water could be detected, and  $\frac{1}{6,000,000}$  to  $\frac{1}{2,000,000}$  of chloride of lithium in urine.

2. *On Rate of Passage into the Textures through the Stomach.*

Even in a quarter of an hour three grains of chloride of lithium, given on an empty stomach, may diffuse into all the vascular textures, and into the cartilage of the hip-joint and the aqueous humour of the eye. In very young and very small guinea-pigs which have received the same quantity of lithium, in thirty or thirty-two minutes it may be found even in the lens; but in an old pig in this time it will have got no further than the aqueous humour. If the stomach be empty, in an hour the lithium may be very evident in the outer part of the lens, and very faintly traceable in the inner part; but if the stomach be full of food, the lithium does not in an hour reach the lens. Even in two hours and a half lithium may be more marked in the outer than in the inner part of the lens. In four hours the lithium may be in every part of the lens; but less evidence of its presence will be obtained there than from the aqueous humour. In eight hours, even, the centre of the lens may show less than the outer part. In twenty-six hours the diffusion had taken place equally throughout every part of the lens. If the lithium is injected under the skin, in ten minutes it may be found in the crystalline lens, and even in four minutes, after the injection of three grains of chloride, the lithium may be in the bile, urine, and aqueous humour of the eye.